PB-19

Automated Measurements for the Characterization of SQUID-Based Time-Division Multiplexing Chips

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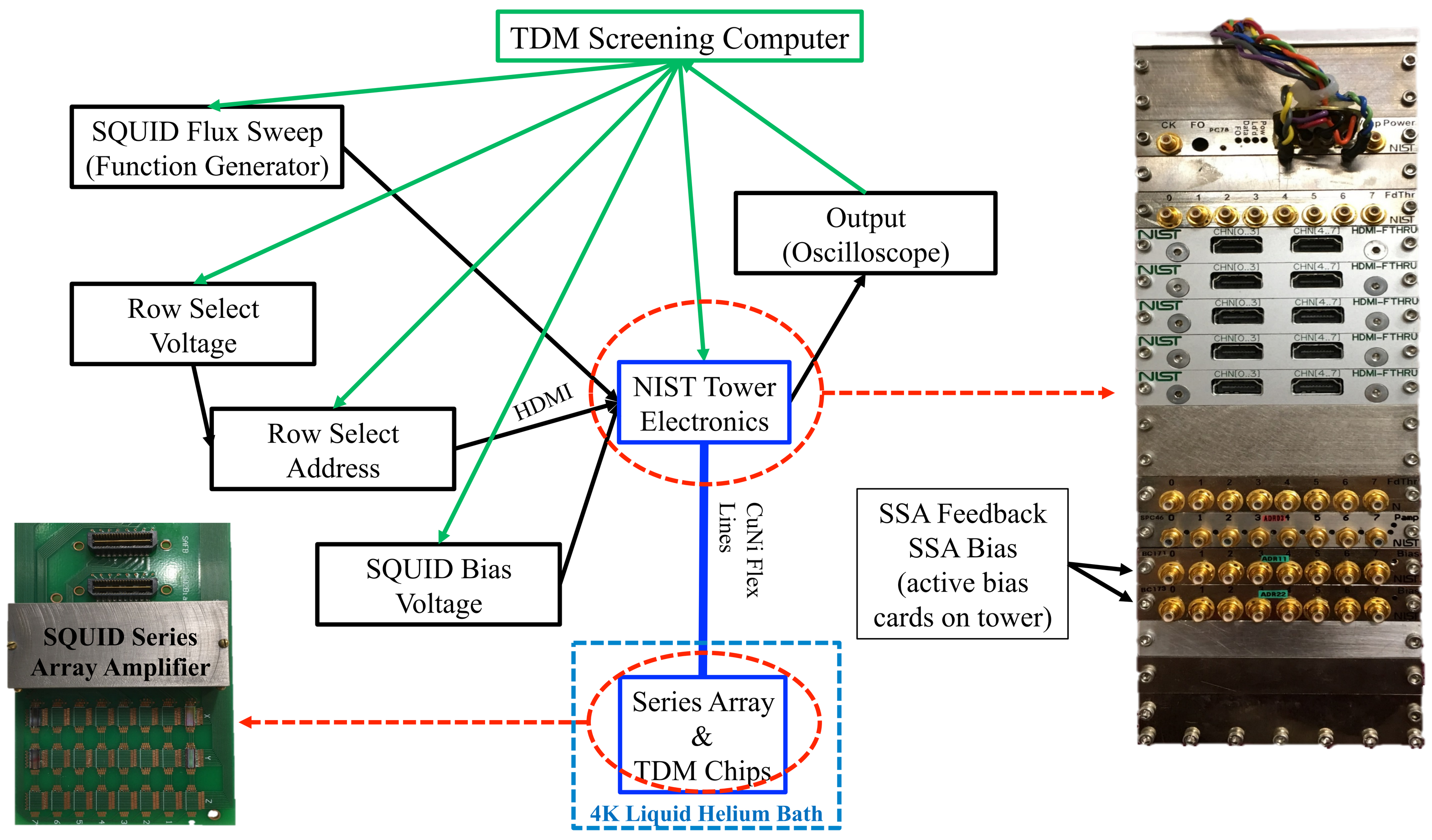
Abstract

SQUID-based time-division multiplexing (TDM) is a mature and widely implemented technology used to read out transition edge sensor (TES) arrays. We describe a suite of software algorithms and automated measurements used to perform detailed TDM chip characterizations and high throughput TDM chip screening at 4 K for projects including Advanced ACT. We show how the new system has been used to probe the physics of mature TDM designs. We also present data for a new (2017) generation of multiplexers (TDM+). These devices implement on-chip flux-activated feedback switches designed to minimize distant pixel crosstalk.

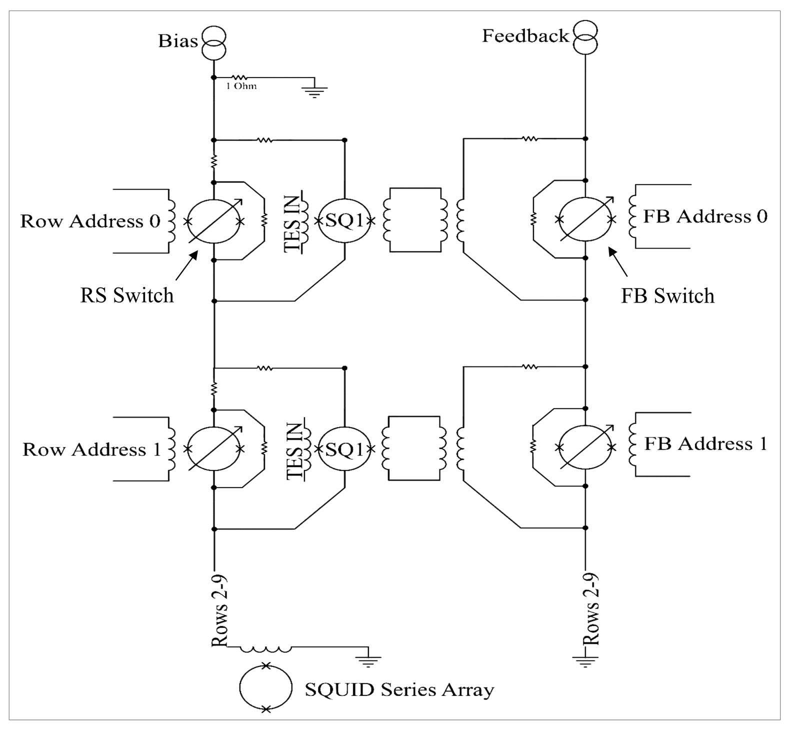
High-Throughput Automated TDM Screening Setup

- Used to screen 240 multiplexer chips for Advanced ACT.
- TDM chips wire-bonded to PCB mounted in a 4K dip probe.
- Measurements use dedicated Python-based automation and analysis software.
- This new software suite takes data, extrapolates information, and produces visualizations of chip characteristics.

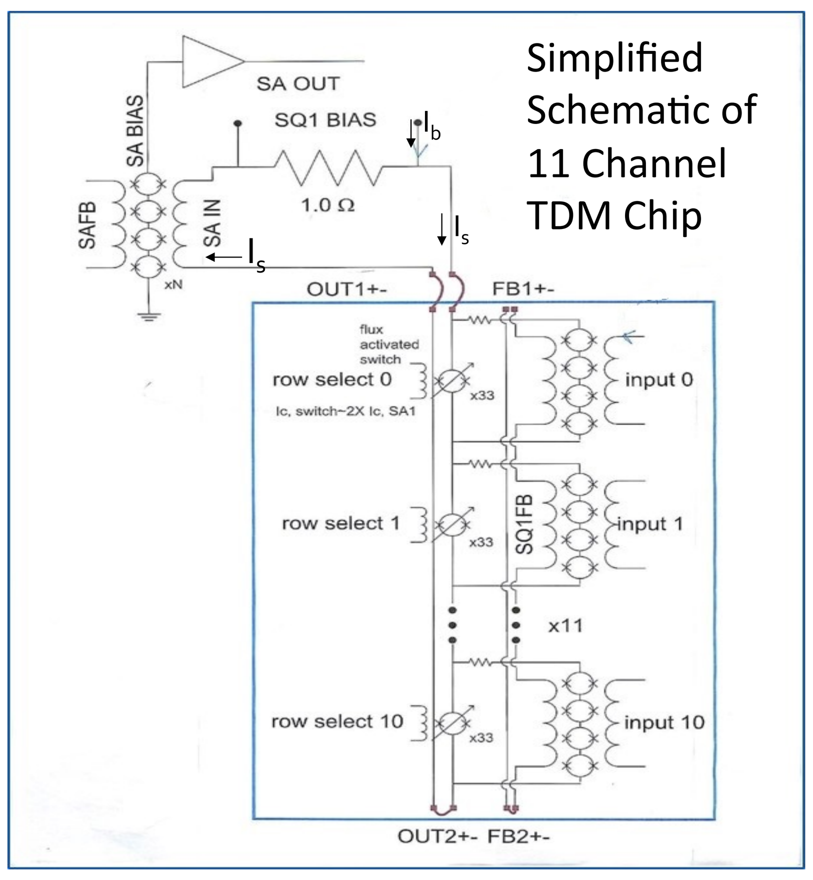


Latest MUX Design: Mux16a

- Mux16a is the most recent generation of time-division multiplexing devices for x-ray calorimeters.
- Mux16a adds flux actuated switches that prevent the flux signal from being applied to 'off' SQUID channels, eliminating a source of crosstalk.
- Row Select (RS) and FB addresses are wired in series, on-chip, so that no new wires are required.



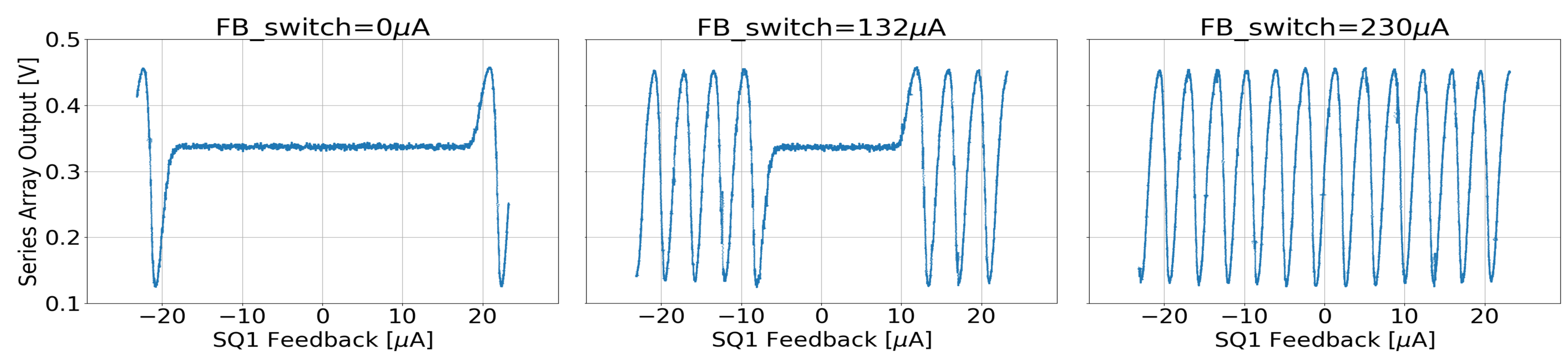
Basic Measurements - TDM Screening at 4K



Simplified Schematic of 11 Channel TDM Chip

- Automated software PID sequentially locks the center of each "SQUID 1" modulation curve to the operating point of a shared SQUID Series Array (SSA) as "SQUID 1" bias is swept from I_b = 0-50 μA
- Determine all "SQUID 1" $I_{c,min}$ and $I_{c,max}$
- Record "SQUID 1" modulation curves and dependence of modulation depth on "SQUID 1" bias (I_b).
- Separately evaluate each flux-activated "row select" (RS) switch for quality and robustness.

New Mux16a switches turn off feedback signal to SQUIDs



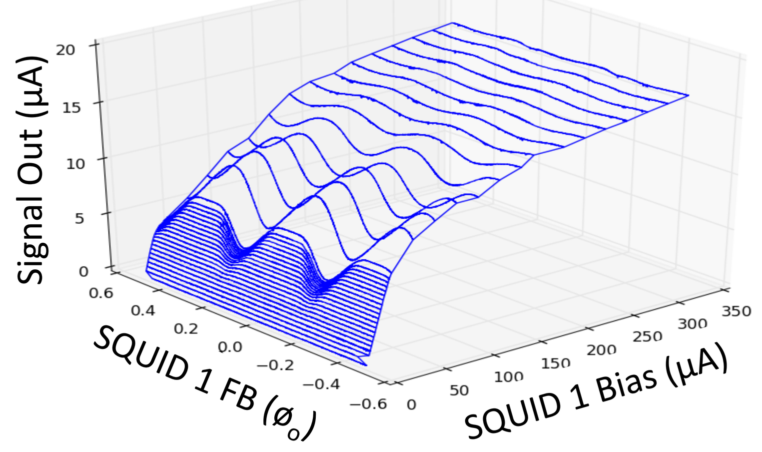
Testing "SQUID 1" FB switch actuation through ½ ϕ_o. **Left:** With feedback (FB) switch closed (OFF) "SQUID 1" shows no response, except when the FB current exceeds the critical current of the FB switch. **Middle**: The FB switch is partially ON. **Right:** The FB switch is resistive (ON). FB current flows through the corresponding FB coil, fully modulating the "SQUID 1" response. [Test conditions: "SQUID1" at nominal bias and Row Select ON (I = 230 μA).]

Acknowledgements

We would like to thank the Advanced ACT collaboration for wire-bonding chips and for invaluable discussions on SQUID readout and characterization. We would also like to thank Zach Steffen for assistance in SQUID screening during summers 2015 and 2016.

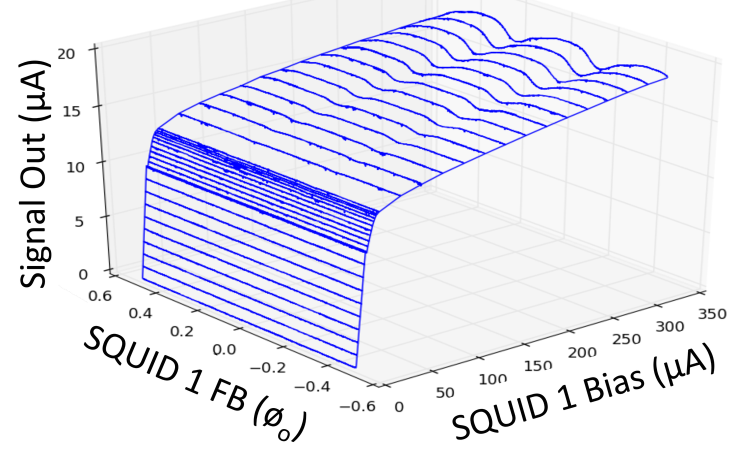
Automated TDM Testing - Output

"SQUID 1" Response – RS Switch ON

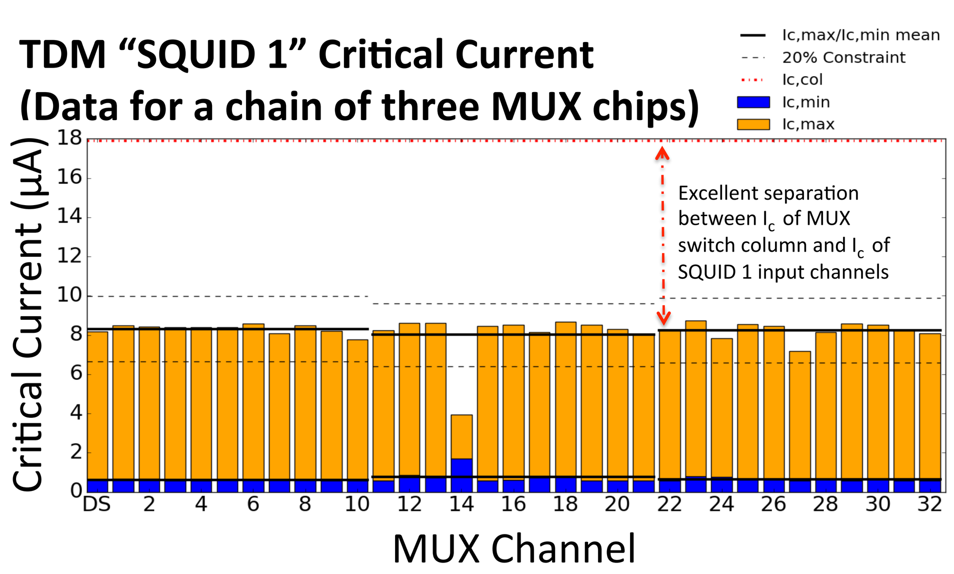


High-throughput screening (bottom row) as well as detailed SQUID characterization (left and right). Automated high-throughput TDM screening is ~40x faster and ~ 5x more precise than manual screening.

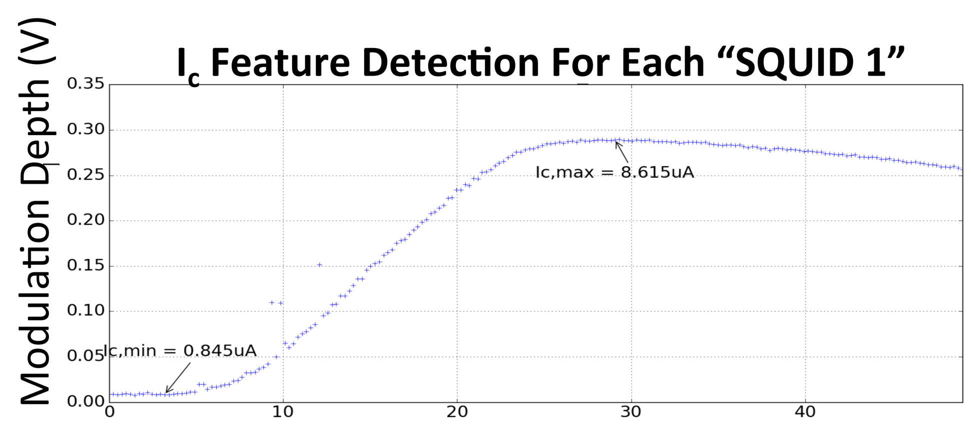
"SQUID 1" Response – RS Switch OFF



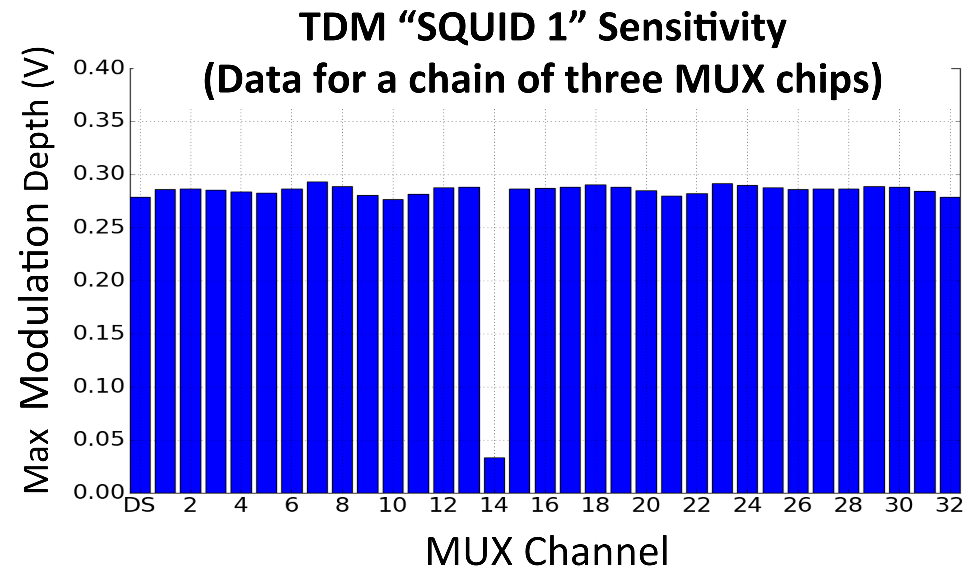
TDM "SQUID 1" Critical Current (Data for a chain of three MUX chips)



I_c Feature Detection For Each "SQUID 1"



TDM "SQUID 1" Sensitivity (Data for a chain of three MUX chips)



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